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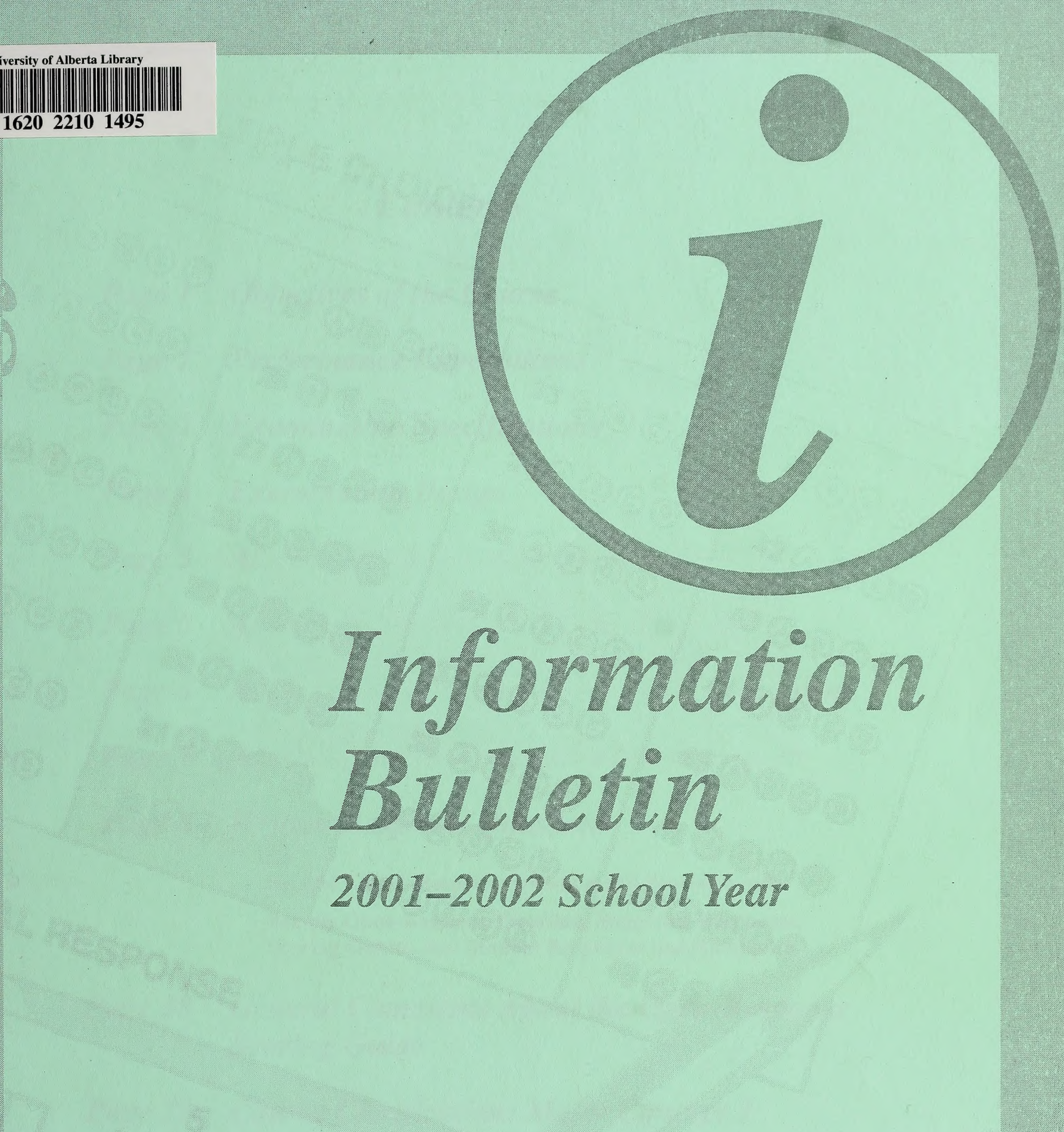

Information Bulletin

2001–2002 School Year

Diploma Examinations Program

Alberta
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Objectives of the Course

Biology 30 is intended for students who want to better understand the biology principles behind the natural events they experience and the technology they use in their daily lives. Biology 30 is an experimental discipline requiring creativity and imagination. It develops the knowledge, skills, and attitudes to help students become capable of and committed to setting goals, making informed choices, and acting in ways that will improve their own lives and life in their communities.

Students of Biology 30 will develop their aptitude for observing, collecting facts, forming generalizations, hypothesizing, and making inferences from observations. They will show growth in their understanding of biological concepts by their increased ability to apply these concepts to relevant situations. They will learn to communicate in the specialized language of biology.

Success in science courses, and in particular Biology 30, requires the successful completion of Science 10 and Biology 20 and concurrent mathematics courses, which develop the prerequisite knowledge and skills.

Curriculum Standards

Provincial curriculum standards help to communicate how well students need to perform in order to be judged as having achieved the objectives specified in the *Biology 20–30 Program of Studies, Interim 1995*. The specific statements of standards are written primarily to apprise Biology 30 teachers of the extent to which students must know the Biology 30 content and be able to demonstrate the required skills to be able to pass the examination.

Performance Expectations

Acceptable Standard

Students who achieve the *acceptable standard* in Biology 30 receive a final course mark of 50% or higher. Students who achieve the minimal acceptable standard demonstrate a basic understanding of the nature of scientific inquiry by designing, observing, and interpreting laboratory and field investigations. They solve simple quantitative genetic and ecological problems. These students demonstrate a partial understanding of equilibrium by identifying how some aspects of the human nervous and endocrine systems regulate other body processes such as reproduction. These students interpret short reports of current biological issues through the use of their understanding of some key biological and technological terms. They identify scientific, technological, and societal components of biological problems.

Standard of Excellence

Students who achieve the *standard of excellence* in Biology 30 receive a final course mark of 80% or higher. In addition to meeting the expectations for the *acceptable standard* of performance, these students demonstrate their aptitude and interest in biology and feel confident about their abilities. They readily interpret interrelated sets of data such as complex diagrams, graphs, and tables. They analyze and evaluate experimental designs. These students provide explanations of concepts that are specific but also comprehensive. They simultaneously apply two or more biological concepts that cross major themes. They demonstrate a thorough understanding of quantitative relationships and solve multistep numerical problems. When presenting scientific data, they select the most appropriate form. They analyze complex open-ended issues that are of a new or unique nature including current biological research. These students are aware of a variety of viewpoints relating to environmental and ethical issues in the field of science and technology. They communicate clearly and concisely, using appropriate scientific vocabulary.

Examination Specifications

Each Biology 30 diploma examination is designed to reflect the Biology 30 general learner expectations (GLEs) outlined in the *Biology 20–30 Program of Studies, Interim 1995*. The general learner expectations are expressed in more detail by the specific learner expectations (SLEs), which are organized into four units. Some questions on each diploma examination will assess achievement of specific learner expectations. Some questions will be based on the integration of several specific learner expectations.

All examination questions are organized into sets that relate to broad contexts. Therefore, a set of questions may assess students' ability to integrate several general learner expectations (GLEs). All questions will measure achievement of scientific knowledge; some will also measure achievement of skills and/or STS connections.

The 2001-2002 Biology 30 diploma examinations are constructed to place the following approximate emphases on the Biology 30 course general learner expectations.

Knowledge The student can demonstrate that	***Emphasis***
• humans use nervous and endocrine systems to maintain internal equilibrium among their systems while simultaneously interacting and maintaining equilibrium with the external environment	20–25%
• humans and other organisms have chemically regulated reproductive systems, which ensure survival of the species, and can describe how sexually transmitted diseases interfere with human reproductive function	10–15%
• cell differentiation and organism development are regulated by genetic and environmental factors and that natural processes can be changed by using reproductive technologies	5–10%
• cell division in vascular plants and animals promotes growth, genetic continuity, and diversity of organisms; and that genetic traits are inherited and expressed in predictable ways if chromosome segregation, assortment, and crossing over are taken into account	25–30%
• genetic information stored in DNA molecules directs the functions of organisms and that biotechnology can be used to influence genetic expression	10–15%
• gene frequencies within populations determine the composition of communities and that these gene frequencies may reach equilibrium or continue to change over time as populations interact	15–20%

Scientific Process and Communication Skills	***Emphasis***
The student can	20–30%

- design, interpret, explain, analyze, and evaluate investigations
- organize data into tables, graphs, and diagrams and predict relationships
- interpret, explain, analyze, and evaluate data to infer relationships
- use appropriate scientific terminology and mathematical language to communicate and explain scientific concepts

Science, Technology, and Society Connections (STS)	***Emphasis***
The student can	20–30%

- apply cause-and-effect reasoning to formulate relationships in which scientific evidence shapes or refutes a theory, and explain the limitations of science and technology in answering all questions and solving all problems
- describe and evaluate the design and function of technological solutions to practical problems by using scientific principles and theories, and relate the ways in which science and technology advance one another
- evaluate from a variety of perspectives how science and technology are influenced and supported by society, and assess the ability of society to interact responsibly with the environment
- apply the skills and knowledge acquired in Biology 30 to everyday life and to related and new concepts in post-secondary studies

Examination Design

The design of the 2001–2002 Biology 30 diploma examinations is as follows:

Question Format	*Number of Questions*	*Percentage Emphasis*
Multiple Choice	48	60
Numerical Response	8	10
Written Response	2	30

The machine-scored portion of each examination contains both multiple-choice and numerical-response questions, some of which may be grouped together in sets that relate to specific contexts.

Answers for multiple-choice questions are recorded in the first section of the machine-scored answer sheet. Answers for numerical-response questions are recorded in the second section on the same side of the machine-scored answer sheet. Answers to the written-response questions are written in the examination booklet.

Multiple-choice questions are of two types: *discrete* and *context-dependent*. A discrete question stands on its own without any additional directions or information. It may take the form of a question or an incomplete statement. A context-dependent question provides information separate from the question stem. Most of the multiple-choice questions are *context-dependent*.

Numerical-response questions are of three types: calculation of numerical values; selection of numbered events, structures, or functions from a list; and determination of a sequence of events. Specific instructions for recording answers for each type of numerical-response question are provided in the instruction pages of each Biology 30 diploma examination and with each question. Note that the correct answer for any one question will not necessarily require the use of all four columns in the grid provided on the answer sheet.

A particular context may be used for one or more multiple-choice questions and/or one or more numerical-response questions.

The **written-response** portion of the Biology 30 diploma examination contains two contextual questions: a closed-response question and an open-response question. Each question has a value of 15%.

The closed-response question (Written Response 1) presents a synopsis of current research. Pertinent data are provided in the form of graphs and/or tables. The various parts of this question may require students to demonstrate a variety of science process skills.

The open-response question (Written Response 2) also presents a problem based on current research. It requires students to make connections among biological concepts, technology, and/or social issues. The response to this question is expected to have complete sentences and paragraphs, and to be presented as an expository composition in which the student is expected to explain, describe, or provide an argument.

For the open-response question, students are given a writing space consisting of three blank pages alternating with three lined pages. This writing space will be the same for every Biology 30 diploma examination. In addition, blank perforated pages are provided at the back of every Biology 30 diploma examination.

Assessment of STS Connections

Examination questions measure the students' understanding of biological concepts. Some questions also measure the students' development of the skills and thinking processes associated with scientific inquiry. Other questions have been designed to measure students' understanding of the interrelationships between science and technology and among science, technology, and society.

Industries, businesses, and post-secondary institutions in Alberta have been helpful in providing real-life contexts for STS questions, as well as in making connections between real life and the curriculum. The contributions of these institutions have enhanced the quality of the diploma examination program in Alberta.

The development of test items, from the writing stage until they appear on an examination, may take a number of years. For the 2001 Biology 30 Diploma Examination, we would like to recognize the contributions of the following institutions and companies.

Beefbooster, Calgary
Royal Tyrell Museum, Drumheller
Surgical Medical Research Institute, University of Alberta, Edmonton

Assessment of Communication Skills

Communication skills are assessed most directly in the marker-scored questions. For the open-response question, the descriptions used in the scoring guides may include criteria for assessing communication skills along with criteria for assessing biological content.

The term *communication skills* includes those processes by which information is expressed using appropriate conventions. These conventions include:

- words, sentences, paragraphs
- graphs, diagrams, tables
- mathematical formulas, mathematical and chemical equations
- significant digits, units of measurement, unit conversion

Conventions that are considered appropriate for a particular response are subject- and question-specific.

Archived Information from Previous Bulletins

NEW

Each bulletin contains unique information of value to teachers, especially teachers new to the program. Information such as course clarifications, reminders and explanations, and definitions of terms that are relevant to the diploma examination program can be found in the *Archived Information* section of specific subject bulletins on the web site (http://www.learning.gov.ab.ca). Only information that is applicable to current diploma examination programs has been archived.

Year	**Topic**
2000–2001	Internet Sites Recommended for Alberta Students and Teachers
1999–2000	Internet Sites Recommended for Alberta Students and Teachers – Hardy-Weinberg Calculations – Implementations of the New Open-Response Scoring Guide
1998–99	Development of the New Open-Response Scoring Guide
1997–98	Science and Technology (descriptions of various genetic technologies and their uses) Science, Technology, and Society Issues in Science, Technology, and Society Relationships Among Organisms of Different Species
1996–97	Pedigree Analysis Chromosome Formation Counting Chromosomes Succession Graphing
1995–96	Chromosome Number Descriptions Genetic Conventions

Assessing the Information and Communication Technology (ICT) Outcomes in Biology 30

NEW

The *Biology 30 Program of Studies* has knowledge, skill, and society/technology outcomes that overlap with the *Information and Communication Technology Program of Studies*; therefore, some of the outcomes listed in the ICT program are currently being assessed on provincial examinations. Alberta Learning will continue to evaluate ICT outcomes on diploma examinations. Listed below are a few examples of overlap between the ICT program and the *Biology 30 Program of Studies*.

Biology 30 Program of Studies	***ICT Program of Studies***
Students discuss and evaluate the effects of science and technology on longevity and quality of life (Unit 3 Major Concept 1 STS).	• Students will seek alternative viewpoints, using information technology (ICT Outcome C2). • Students critically assess information accessed through the use of a variety of technologies (ICT Outcome C3).
Using computer simulations, students observe and understand principal features of human systems (Unit 1 Major Concepts 1, 2, Unit 2 Major Concept 1, 3 Skills).	• Students will use technology to investigate and/or solve problems (ICT Outcome C6).
Students discuss the implications to society of corporations' use of biotechnology (Unit 3 Major Concept 3 STS).	• Students will demonstrate a moral and ethical approach to the use of technology (ICT Outcome F3).
Students apply quantitatively, the Hardy–Weinberg principle to observed and published data (Unit 4 Major Concept 1 Knowledge).	• Students will manipulate and present data through the selection of appropriate tools such as scientific instrumentation, calculators, databases, and/or spreadsheets (ICT Outcome P2 4.1).

When accessing electronic information, it is important for students to evaluate the authority, reliability, and validity of the information (ICT Outcome C3 4.1) and to identify and analyze factors that affect the authenticity of the information.

Written-Response Questions

Each Biology 30 diploma examination has two written-response questions. The closed-response question (Written Response 1) is presented in several parts and the total number of parts is dependent upon the context. Each part is scored using a closed-response scoring guide. The parts of this question total to a score of 12 worth 15% of the examination. All of the parts of this question are scored by one marker. For an example of a closed-response question and scoring guide, see pages 10 to 13.

The open-response question (Written Response 2) requires an expository composition. In an expository composition, a student is expected to explain or describe something, or to provide an argument. Beginning in January 1999, the open-response question on Biology 30 diploma examinations will be scored using two six-point scoring scales, each with a range of 0 to 5. The “Science” scale assesses a student’s response on the science aspects of the question. The “Technology and Society” scale assesses a student’s response on these aspects of the question. Each bullet on the scoring guides describes a part of the student’s response at the 5, 4, 3, 2, or 1 level. These descriptions are used to award a mark out of 5 for the part of the question that the bullet describes. The average of these marks is then used to determine the overall score for each of the two scales. The “Science” content mark is weighted to be worth twice as much as the “Technology and Society” mark. Each student’s response will be scored independently by two markers. The two Science content scores will be added together for a combined sub-score out of ten. The two Technology and Society scores will be added together and then divided by two for a combined sub-score out of five. The two sub-scores will be added together for a total out of 15. The open-response question is worth 15% of the biology examination.

A summary of the calculations follows.

Science scale: Marker 1 Score (X out of 5) + Marker 2 Score (Y out of 5) = Sub-score (X + Y out of 10)

Technology and Society scale: Marker 1 Score (X out of 5) + Marker 2 Score (Y out of 5) divided by 2 = Sub-score $\left(\frac{X+Y}{2} \text{ out of } 5\right)$

Final Score = Science (out of 10) + Technology and Society (out of 5) = maximum of 15 marks

If the scores on the Science scale obtained by the two independent markers vary by values of 2 or more, out of 5, or if the scores on the Technology and Society scale obtained by the two independent markers vary by values of more than 2, out of 5, the scores are classified as *discrepant*. Responses that have *discrepant* scores are read by a third marker. The third marker must assign a score that is equal to one of the scores of the first two markers or that is between these scores.

For an example of an open-response question, suggested responses, scoring guides, and sample student responses with scores and rationales, see pages 14 to 28. Students should be made aware of the change in scoring systems for the open-response question.

Sample Closed-Response Question and Scoring Guide

The following question is taken from the June 2001 Biology 30 Diploma Examination.

Use the following information to answer the next question.

Although doctors were astonished, relatives were not surprised when Benjy Stacy was born with skin the colour of a bruised plum. Two days of medical tests to rule out possible heart and lung disease revealed no cause for the newborn's dark blue skin. Not until Benjy's grandmother asked the puzzled doctors if they had ever heard of the blue Fugates of Troublesome Creek was the mystery solved. When baby Benjy inherited his mother's red hair and his father's lankiness, he also received his great-great-great-grandfather Martin Fugate's blue skin.

In 1820, a French orphan named Martin Fugate settled on the banks of Troublesome Creek. He and his red-headed American bride Elizabeth had seven children, four of which were reported to be blue-skinned. Isolated in the hills of eastern Kentucky, the family multiplied. Intermarriages between "blue Fugates" were common. Over time, the inherited blue trait began to disappear as the arrival of railways and roads allowed family members to marry outside their communities. Six generations after Martin Fugate first settled in Troublesome Creek, baby Benjy was born.

Based on Benjy's grandmother's account and further testing, doctors concluded that the newborn carried one copy of a mutated gene for methemoglobinemia. Hereditary methemoglobinemia is a rare autosomal recessive blood disorder. Blue people have an absence of the enzyme diaphorase in their red blood cells. In a normal individual, hemoglobin, the blood's red, oxygen-carrying molecule, is slowly converted to an non-functional blue form called methemoglobin. Diaphorase then converts methemoglobin back to hemoglobin. The absence of diaphorase in affected individuals is caused by a mutation in the enzyme's structural gene. This causes the accumulation of blue methemoglobin, which replaces the red hemoglobin responsible for pink skin in most Caucasians.

—from *Trost, 1982*

1. **a.** Explain how a gene mutation could alter the diaphorase enzyme's amino acid sequence. **(2 marks)**

A gene mutation alters the nitrogen-base sequence of the gene's DNA. (1 mark) This change in the sequence results in an altered mRNA nitrogen-base sequence that, in turn, can alter the amino acids in the diaphorase enzyme. (1 mark)

Use the following additional information to answer the next three parts of the question.

In one account of the Fugate family's pedigree from 1750 to 1889, six of the 55 individuals expressed the blue phenotype as adults.

b. Determine the frequency of the recessive allele for the Fugate family during this time. Show your work. **(2 marks)**

$q^2 = \frac{6}{55} = 0.11$ *(1 mark)*

$q = 0.33$

The frequency of the recessive allele is 0.33. (1 mark)

c. Predict the theoretical percentage of individuals in the Fugate family that were heterozygotes during this time. Show your work. **(2 marks)**

$p + q = 1$
$1 - 0.33 = p$
$p = 0.67$
$2pq = 2(0.33)(0.67) = 0.44$ *(1 mark)*

Theoretically, 44% of the individuals were heterozygous for the allele. (1 mark)

d. Explain why the frequency of the blue skin phenotype was higher in the Fugate family than in the general American population. **(1 mark)**

The mutation first occurred in an individual in the Fugate family; therefore, more members of this family have the allele than do the general population.
or
Intermarriage within the Fugate family increased the probability of two carriers mating and producing blue offspring.
or
Because the Fugate family lived in an isolated area, the likelihood of carriers mating and producing blue offspring increased.

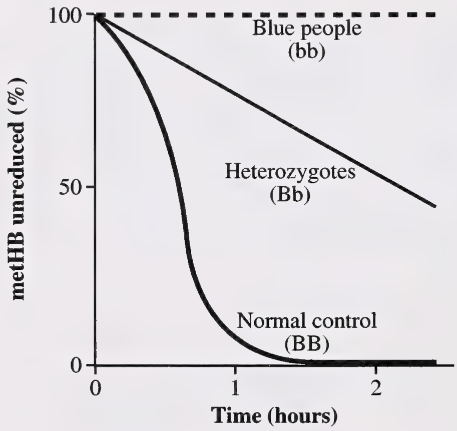
e. Identify two ways in which the population, which consisted of six generations of the Fugate family, did not meet the conditions for Hardy–Weinberg equilibrium. **(2 marks)**

Any two of the following:

- *The population was small, and a large population is required to meet the conditions for Hardy–Weinberg equilibrium.*
- *There was non-random mating rather than the random mating required for Hardy–Weinberg equilibrium.*
- *Mutation occurred to produce the defective diaphorase, and Hardy–Weinberg equilibrium requires no mutation.*
- *Emmigration or immigration from the population occurred, and migration does not occur in populations that satisfy Hardy–Weinberg equilibrium.*

Use the following additional information to answer the next part of the question.

RBC NADH Diaphorase Activity



The data above were obtained by extracting red blood cells from three different groups of individuals. The red blood cells were then evaluated for their ability to convert methemoglobin to hemoglobin.

—from *Huskey, 1996*

f. Although he was very blue at birth, within his first few weeks, Benjy's skin colour changed to normal with no treatment required. At the age of seven, other than purplish blue lips when he was cold or angry, Benjy's colouration was normal.

i. What is Benjy's genotype? **(1 mark)**

Bb (heterozygous)

ii. Give a possible explanation for the change in Benjy's phenotype over time. **(1 mark)**

- *Benjy produced some normal diaphorase and, over time, was able to convert enough methemoglobin into hemoglobin to express a normal skin colour.*
  or
- *Fetal hemoglobin is different than adult hemoglobin. Therefore, the expression of Benjy's phenotype may have changed shortly after birth.*
  or
- *Any other reasonable explanation.*

iii. Individuals with hereditary methemoglobinemia can be treated easily with methylene blue pills. Methylene blue acts as an "electron donor" converting methemoglobin to hemoglobin, which results in pink skin colouration. Explain why treated blue people can still produce offspring with hereditary methemoglobinemia. **(1 mark)**

Treatment does not change the alleles present in the germ cells of the individuals, which can still be passed on to future generations.

Credits

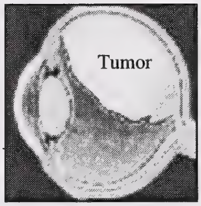
Cathy Trost. From "The Blue People of Troublesome Creek" as found on http://wsrv.clas.virginia.edu/~rjh9u/blkysc82.html. Adapted and reprinted with permission from Cathy Trost.

Diagram by Robert J. Huskey. From www.people.virginia.edu/%7erjh9u/diaenz.html. Adapted and reprinted with permission from Robert J. Huskey, University of Virginia.

Sample Open-Response Question, Suggested Responses, Scoring Guides, and Sample Student Responses and Rationales

Use the following information to answer the next question.

Retinoblastoma



–from *American Association for the Advancement of Science, 1996*

A child has retinoblastoma, a retinal cancer that can be fatal. The tumour is visible in the image above.

Childhood tumours of the retina are associated with the inactivation of the retinoblastoma gene. Retinoblastoma is the most common malignant eye tumour of childhood. It occurs in about 1 in 20 000 live births. The disorder is caused by tumour cells that develop in one or both eyes in children under five years of age. It is usually diagnosed initially by a bright white or yellow mass in the pupillary area behind the lens.

There are hereditary and non-hereditary forms of retinoblastoma. In hereditary retinoblastoma, there is a germ cell mutation that predisposes the individual to the development of the retinal tumour.

Retinoblastoma is almost uniformly fatal if not treated in its early stages. Cancer tumour cells can quickly spread throughout the body to form new tumours, a process called metastasis. However, with early diagnosis and modern methods of treatment, the survival rate is over 90% for people with retinoblastoma.

The gene responsible for the hereditary cases of retinoblastoma is found on chromosome 13 and is believed to belong to a class of human cancer genes that are **regulatory** in function. Retinoblastoma results when a retinal cell of an individual has two inactivated versions of the gene. However, inheriting only **one** copy of the mutated gene increases the risk of developing the disease. The second mutated gene necessary to display the phenotype arises by random mutation (30%) or by abnormal crossing over during mitosis (70%). The normal protein for which the gene codes plays a role in the control of the cell cycle. In the absence of the normal protein, a cell will continue into the next cell division without an opportunity to become quiescent. This uncontrolled division leads to cancer.

2. Write an expository composition on how retinoblastoma affects a person, develops, and is diagnosed, and explain and how its incidence can be reduced in a population.

- **Explain** how retinoblastoma could interfere with the normal processes involved in sight. **Provide** the necessary details of the physiology of the eye and brain.
- **Diagram** the phases of the cell cycle and explain how the cell cycle would be affected in cells of an individual homozygous for the inactivated regulatory gene associated with retinoblastoma.

- **Explain** genetic counselling, constructing example crosses to aid in your explanation, or explain genetic screening. **Explain** how the information gathered by either genetic counselling or genetic screening could be used to help reduce the incidence of retinoblastoma in the population.

Illustration Credits

Photograph reprinted with permission from http://www.ncbinlm.nih.gov/cgi-bin/SCIENCE96/gene? RBI. Copyright 1996 American Association for the Advancement of Science. Readers may view, browse, and/or download this material for temporary copying purposes only, provided these uses are for non-commercial personal purposes. Except as provided by law, this material may not be further reproduced, distributed, transmitted, modified, adapted, performed, displayed, published, or sold in whole or in part, without prior written permission from AAAS.

Suggested Responses

Interference with Normal Vision

The tumour develops in and among the retinal cells of the eye. The retina normally changes light stimuli into electrical impulses. The optic nerve then transmits these impulses to the occipital lobe of the cerebrum, which interprets the impulses to produce sight. The tumour therefore results in blindness.

or

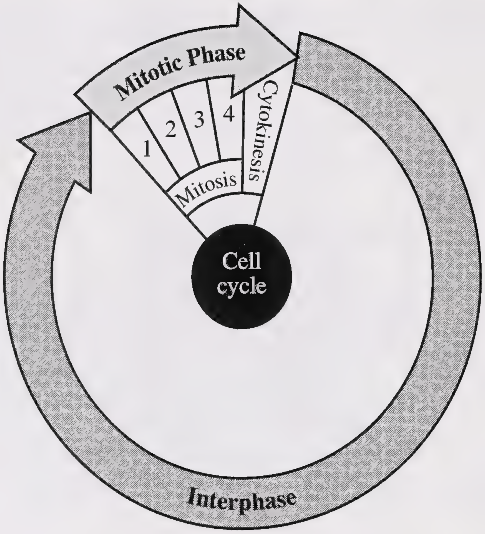
A diagram could also be used to show disruption of vision by the tumour and of the function of the parts involved.

or

Some students may identify damage to the vitreous humour, optic nerve, and/or choroid coat, as well as to the retina. (These are reasonable hypotheses based on the photograph of the eye showing the tumour location.) The tumour obstructs the normal function of these parts by interfering with focusing, neural transmission, and/or light refraction, respectively.

Phases of the Cell Cycle and Disruption by the Abnormal Gene

The cell cycle diagram should be complete and should show a relatively long interphase. (Interphase may be divided into G_1, S, and G_2 phases, but this is not necessary.)



An individual who is homozygous for the inactivated cell control gene will not produce a normal protein for this function. The cell will not enter interphase or will have a shorter interphase because of the missing regulatory or control protein. This will result in more cell reproduction than normal, which results in a tumour. Normally, retinal cells only divide during growth of a tissue and when replacing damaged cells. During interphase, cells carry on their normal cell functions.

Genetic Counselling

The abnormal allele for control of cell division in the retinal cells is recessive. This means two copies are necessary to display the phenotype and develop the cancer tumour. However, since the second recessive allele usually arises in the individual because of a mutation or abnormal mitosis, only one copy of the abnormal allele is necessary for increased risk of developing retinoblastoma.

Crosses

If an individual has retinoblastoma, he or she may be genotypically homozygous for the abnormal allele ***or*** *only some of the retinal cells may be homozygous for the allele and the rest of their cells may be heterozygous. (A heterozygous individual can develop a second mutated allele in their retinal cells. The heterozygous state is a risk factor.) If the individual marries an unaffected individual (without the risk factor), the probability of their children inheriting the mutated allele is shown by the crosses below.*

R – normal allele
r – abnormal allele

Heterozygous Parent

	R	*r*
R	*RR*	*Rr*
R	*RR*	*Rr*

In this case, the probability is that 50% of the children will have the risk factor and be carriers of the abnormal allele.

Homozygous Parent

	r	*r*
R	*Rr*	*Rr*
R	*Rr*	*Rr*

In this case, the probability is that 100% of the children will have the risk factor and be carriers of the abnormal allele.

Note: *This is a very unusual type of inheritance. If the students response indicates a straight recessive inheritance and it is well described, the response could be assigned a 4. If an understanding of "risk" is demonstrated, the student could have earned a 5.*

OR

Genetic Screening

Genetic screening could be used to determine the genotypes of the parents or of a fetus. In genetic screening, a biochemical test might be used to determine if the inactive or active protein coded for by the gene was present in an individual's cells. If both proteins (normal and abnormal) are present, the individual is a carrier of the risk factor. If only the inactive protein is present, the individual is homozygous for the disease allele. If only the normal protein is present, the individual is homozygous for the normal allele, and therefore is not at risk.

or

Complementary DNA probes for the mutant allele DNA code and for the normal allele DNA code could be mixed with the single strand DNA of a parent or a fetus. If both types of DNA bind to the individual's DNA, the individual is a carrier for the disease allele. If only the mutant DNA binds, the individual is homozygous for the disease allele. If only the normal DNA binds, the individual is free of the disease allele, and therefore is not at risk.

Note: *Since genetic screening can be used to determine the fetal genotype, a well-written answer would not require crosses. If only parental genotypes are determined by genetic screening, then appropriate crosses should be shown.*

Reduction of the Incidence of the Disease

In order to reduce the incidence of retinoblastoma in the population, individuals affected would have to reduce the number of offspring they had with the abnormal gene. They could be counselled to consider adoption or to remain childless.

or

Alternatively, a method of identifying the risk gene through amniocentesis and DNA analysis using markers could be used to identify carrier fetuses that could then be aborted or treated earlier to reduce the effects of the disease.

or

If a parent is heterozygous, in vitro fertilization could be used and only unaffected embryos (identified by genetic screening) would be implanted in the uterus.

SCIENCE

Score	Scoring Criteria
5 **Excellent**	• A specific structure (e.g., the retina) is logically linked, using appropriate scientific vocabulary, to the tumour location, its normal function, and the disruption of the structure by the tumour. • The pathway of conversion of light into electrical impulses that travel through the optic nerve to the occipital lobe of the cerebrum for interpretation is clearly explained. • A clear diagram of the cell cycle showing mitosis, cytokinesis, and interphase (or G_1, S_1, G_2) is drawn. Interphase is significantly longer than mitosis. • A logical explanation links abnormal genes to an abnormal regulatory protein and to a shortened interphase, which results in a tumour.
4 **Proficient**	• A specific structure is linked, using some appropriate vocabulary, to the tumour location, its normal function, and the disruption to it by the tumour. • The pathway from the sensory structures to the optic nerve to the cerebrum of the brain is described. • A clear diagram of the cell cycle showing mitosis, cytokinesis, interphase **or** mitosis, and G_1, S, and G_2 (divisions of interphase) is drawn. • An explanation links abnormal genes/abnormal proteins to a shortened interphase, which results in a tumour.
3 **Satisfactory**	• A structure of the eye is named and its function is described. A link to the tumour and abnormal vision is suggested. • The function of the cerebrum of the brain in interpreting vision **or** the function of the optic nerve in transmitting information to the brain is described. • A diagram of the cell cycle showing mitosis and interphase is drawn. • A link between the abnormal gene and a shortened interphase or continuous cell division is suggested.
2 **Limited**	• A structure of the eye that is disrupted is identified, or a disruption to the eye is described. • The tumour's role in disrupting the pathway of information to the brain is suggested. • A diagram of the cell cycle is attempted. • Abnormal cell division is linked to cancer.
1 **Poor**	• Only one of the four bullets is addressed.

INSUFFICIENT is a special category. It is not an indication of quality. It should be assigned to papers that do not contain a discernible attempt to address the issue presented in the assignment or that are too brief to assess in this or any other scoring category.

TECHNOLOGY AND SOCIETY

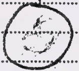
Score	Scoring Criteria
5 **Excellent**	• Genetic counselling is described for individuals of varying genotypes. The concept of risk is addressed. At least two crosses (with correctly identified allele symbols) that support the genetic counselling are shown. **OR** A genetic screening technique that addresses the concept of risk for parental genotype crosses or for fetal genotype results is well described. • A method for decreasing the incidence of the disease allele is identified, and the way in which it will reduce the incidence of the disease is explained.
4 **Proficient**	• Appropriate genetic counselling is described and one supporting cross is shown. **OR** An appropriate genetic screening technique is described. • A method for decreasing the incidence of the disease allele is identified, and the way in which it will reduce the incidence of disease is suggested.
3 **Satisfactory**	• Appropriate genetic counselling is partially described or an appropriate cross is partially completed. **OR** Appropriate genetic screening is partially described. • A method for decreasing the incidence of the disease allele is identified.
2 **Limited**	• A description of genetic counselling is attempted. **OR** One appropriate cross is attempted. **OR** An explanation of genetic screening is attempted. • A method for decreasing the incidence of the disease allele is suggested.
1 **Poor**	• Only one of the two bullets is addressed, and it is scored as either Satisfactory or Limited.

INSUFFICIENT is a special category. It is not an indication of quality. It should be assigned to papers that do not contain a discernible attempt to address the issue presented in the assignment or that are too brief to assess in this or any other scoring category.

Student Sample 1

Retinoblastoma blocks light from entering the eye. Normally, light enters the eye through the lens and hits the retina at the back of the eye. The light wavelengths hit the cones and rods within the retina. This causes an impulse that runs through the optical nerve of the eye and travels to the brain. The nerve impulses are then interpreted by the occipital lobe of the cerebrum in the brain and the person can see. With this disorder however, light cannot get past the lens mentioned in the first stage above, and therefore, vision is obscured or greately reduced.

Interphase:

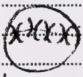


-cell synthesizes proteins and DNA is replicated

Prophase

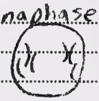
-centrioles split to opposite ends of cells

Metaphase



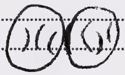
-chromosomes align along spindle fibers

Anaphase:



-chromosomes split to opposite ends of cells

Telophase



-cytokinesis occurs and cells divide into two daughter cells

In this cell cycle, the genes located on the chromosomes would be passed to the next generation of cells after It duplicates and divides into two new cells. This would spread the tumor throughout the eye. The cells divide more rapidly and cannot develop and function as normal cells.

Science Content Score—4

Scoring Guide Bullet	Score	Rationale
1	5	This student gives a very good explanation of how retinoblastoma affects the normal processes involved in sight.
2	5	The student makes reference to rods and cones within the retina and explains that impulses are formed there. The student then mentions that an impulse is transmitted to the brain (occipital lobe) by way of the optic nerve. It is logical that if light cannot stimulate the photoreceptors, a disruption of vision results.
3	2	For the portion of the question dealing with the cell cycle, the student includes interphase and the phases of mitosis. A brief description of what is happening in each of the phases is given. However, there is no indication of how much time is spent in interphase as compared with mitosis, which is an important point. According to the student's diagrams, it would appear that more time is spent in mitosis. The student should indicate that much more time is spent in interphase (90%) than in mitosis. A cell-cycle diagram is not provided.
4	2	The student fails to make the connection between the shortened interphase and cancer. The student does mention that the cells divide more rapidly, which is a characteristic of cancer. This point can be considered as a link to cancer.

Total = 14 14/4 = 3.50 Score = 4

Technology and Society Score—Insufficient

The student did not address the issues of genetic counselling, risk, crosses, and/or genetic screening. There was no attempt made to explain or suggest how the information gathered could be used to reduce the incidence of retinoblastoma in the population.

Final Score

4(2) = 8/10	Science
0/5	Technology and Society
8/15	Final Score

Note: If this student had addressed the Technology and Society portion of the question, he or she would have done much better overall on the question. It is very important that students do all parts of the question.

Student Sample 2

Retinoblastoma is a retinal cancer that develops in the eye. This cancer can be hereditary or non-hereditary. It is caused by the absence of both retinoblastoma genes on chromosome 13. this form develops at a very young age. Retinoblastoma, if not treated could have severe effects on the vision of the person. With a tumor covering the retina, the image cannot focus properly causing some blindness. It is probably hard to make out details as the fovea centralis could be covered and incapable of functioning properly. The tumor could also inhibit the rods + cones, making it hard to see in the dark and black and white vision in the daytime. With a tumor in one eye and not the other, the information to the brain converging could be affected. The one optical nerve may not be able to function properly and the occipital lobe will not receive all the information it needs to interpret the information properly.

In induviduals that are homozygous for the inactivated retinoblastoma gene, the cell division will be uncontrolled, leading to cancer and tumors. First of all, the cause of retinoblastoma could be abnormal crossing in prophase of mitosis, leaving the induvidual with two inactivated retinoblastoma genes on Chromosone 13. Mitosis would then continue through metaphase, anaphase and telophase as well as interphase, only it would be continuous, not controlled and new cells would be made when they are not needed. there will be many unnecesary cells, causing the formation of a malignant tumor.

DNA fingerprinting can be done to find out if one is homozygous or heterozygous for retinoblastoma before any symptoms are expressed phenotypically. Through genetic councelling, it can be determined what the probability is of passing on the disease to the offspring. For example if rr = the inactivated retinoblastoma genes then, when two heterzygous induviduals are mated, the probability of having a child who expresses the trait indefinately is 25%. The heterozygous induviduals are at a greater risk of developing retinoblastoma therefore there is a 75% chance of an offspring developing it from two heterozygous Induviduals. When people are made aware of this, they can decide not to have

	R	r
R	RR	Rr
r	Rr	rr ← 25%

children, lowering the incidents of retinoblastoma. People also can be prepared to treat retinoblastoma If they know the offspring will be predisposed to the trait, reducing the number of fatal cases of retinoblastoma.

Science Content Score—3

Scoring Guide Bullet	Score	Rationale
1	5	This student gives a logical explanation as to how retinoblastoma affects the normal processes involved in sight. The student mentions three structures associated with vision: the rods and cones, the optic nerve, and the occipital lobe.
2	4	The student describes the pathway of conversion of light into electrical impulses. Rods, cones, the fovea, the optic nerve, and the occipital lobe are mentioned, but the explanation is vague.
3	0	A diagram of the cell cycle is not provided.
4	3	The student indicates that because of the retinoblastoma gene, control over the cell cycle would be lost and a malignant tumour would result. No link was made to an abnormal regulatory protein or shortened interphase.

Total = 12 12/4 = 3.00 Mark = 3

Technology and Society Score—5

Scoring Guide Bullet	Score	Rationale
1	4	The student indicates that through genetic counselling, it is possible to determine the probability of passing on the disease to offspring. One cross involving two heterozygous individuals is performed, and the idea of increased risk in the heterozygous condition is presented.
2	5	A method for decreasing the incidence of the disease allele based on information gathered is identified (not having children, treatment). An explanation of how this method will reduce the incidence of the disease is given.

Total = 9 9/2 = 4.5 Mark = 5

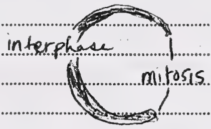
Final Score	3(2) = 6/10	Science
	5/5	Technology and Society
	11/15	Final Score

Note: This student did an excellent job on the Technology and Society part of the response. However, the Science section is worth twice the amount of marks toward the student's overall mark.

Student Sample 3

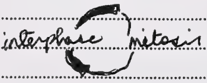
Patients suffering from retinoblastoma experience the growth of a malignant tumor in the pupillary area behind the lens. This would affect normal processes involved with sight because the tumor prevents an image from focusing on the retina. Therefore, retinoblastoma causes a serious impairment of sight, if not blindness, depending on its size. The cones and rods situated on the retina would not work properly in patients (even those in initial stages) because the tumor would impede on their functioning. Cones and rods are used to see color and shades of grey respectively. The different images they receive are transmitted to sensory nerves and then to the brain. Therefore, if they are not functioning then the brain will not receive impulses from them in order for the patient to see.

Phases of the Cell Cycle In a Normal Individual



- Interphase includes the growth of the cell during M_1 and M_2 and the replication of DNA during 'S' phase.
- Mitosis is where the cell divides to produce two daughter cells.

Phases of the Cell Cycle in an affected Individual



- Time spent on mitosis is significantly increased. Therefore, less time is spent for the cells growth and specialization. Cell division is occuring at a much faster pace, which is common in tumors. This cell's fast mitosis means that the tumor is active and may spread cancer to other areas of the body through metastasis.

Using crosses, genetic counseling and genetic screening doctors can figure out the risk of a couple having an affected child according to their own alleles for the disorder. With genetic screening, doctors can identify retinoblastoma at early stages, where the survival rate is 90%. Because the disorder occurs in children under five years of age. it is advantageous to identify the disorder or the risk of the disorder as early as possible. These techniques can reduce the number of deaths caused by the disease.

Science Content Score—4

Scoring Guide Bullet	Score	Rationale
1	5	This student logically linked specific structures (retina, rods, cones) to the tumour location, normal function, and disruption made by the tumour.
2	3	The student stated the tumour's role in disrupting the pathway of information to the brain. Rods and cones, sensory nerves, and the brain are used to explain the disruption. The cerebrum, occipital lobe, and optic nerve are not identified, nor is the interpretation of vision addressed.
3	4	The student's diagram of the cell cycle shows interphase and mitosis. Interphase represents a larger portion of the diagram than does mitosis—an important point. The student incorrectly identifies M1 and M2 (likely meant G1 and G2) as being a part of interphase, but does say that replication of DNA occurs during the S phase. Cytokinesis is not mentioned.
4	3	Abnormal cell division is linked to cancer. No link was made to the abnormal regulatory protein. However, a link to the gene is suggested when the student indicates that because mitosis is occurring at a faster rate with a shortened interphase, a tumour would develop.

Total = 15 15/4 = 3.75 Mark = 4

Technology and Society Score—1

Scoring Guide Bullet	Score	Rationale
1 & 2	1 (total)	An explanation of genetic counselling is attempted. No crosses are performed, and no method for decreasing the incidence of the disease allele is given. The student states that it is possible to figure out the risk of a couple having an affected child but does not go beyond this statement.

Final Score

4(2) = 8/10	Science
1/5	Technology and Society
9/15	Final Score

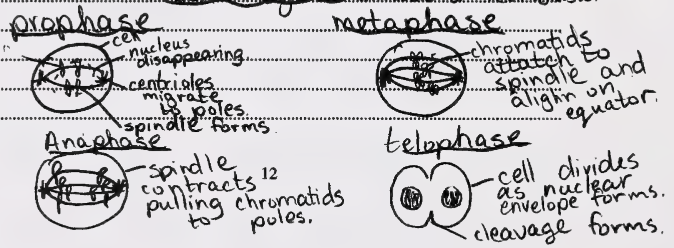
Student Sample 4

Retinoblastoma is a cancer of the eye that is both genetically and non-genetically linked. It can be fatal if not caught in its early stages by spreading to the rest of the body.

Retindblastoma would interfere with sight because the tumor is located inside the eye taking up part of or all of the retina, and can block the optic nerve and fovea centrallis. This impairs vision by blocking some or all of the light travelling through the lens, thus affecting the image portrayed on the retina. The optic nerve carries these affected images to the cerebrum for interpretation. In the picture above the tumor affects only one eye, which will adversely affect this individual's perception of depth, which requires both eyes.

Cancer cells, such as the retinoblastoma cells can reproduce much quicker than normal cells, putting a risk on the rest of the body cells for spreading.

Cell cycle (mitosis of retinoblastoma cells)


prophase
cell
nucleus disappearing.
centrioles migrate to poles.
spindle forms.
metaphase
chromatids attatch to spindle and alighn on equator.
Anaphase
spindle contracts
12
pulling chromatids to poles.
telophase
cell divides as nuclear envelope forms.
cleavage forms.

An individual homozygous for the inactivated gene, would have affected cells. The DNA of the retinoblastoma cells would code into the individual's DNA, producing proteins of these cancer cells. The DNA would be replicated through cell division, and soon would lead to cancer through accelerated division.

In heriditary forms of retinoblastoma, because of the knowledge of the gene being on chromosome 13, DNA reconstruction maybe could be done in the future.

For now genetic crosses could be examined,

ex:#1 R^r= retinoblastoma gene.

R^R= normal cell.

	R^r	R^R	genotype	phentype
R^R	$R^R R^r$	$R^R R^R$	½ $R^R R^r$	50% normal cell, 50%
R^R	$R^R R^r$	$R^R R^R$	½ $R^R R^R$	chance of retinoblastoma.

Using crosses such as these geneticists could determine those who carry the genes and determine possible offspring outcomes using this information By monitoring individuals with both genes, the disease can be caught early and eliminated effectively.

Science Content Score—3

Scoring Guide Bullet	Score	Rationale
1	5	This student logically linked specific structures (retina, optic nerve, fovea) to the tumour location, normal function, and the disruption made by the tumour.
2	3	The student's description of the pathway of conversion of light into electrical impulses has gaps. Rods, cones, or sensory receptors are not directly mentioned. (The fovea is identified.) The occipital lobe is not identified. The link is made that the optic nerve carries the affected images to the cerebrum for interpretation.
3	2	The student attempts a diagram of the cell cycle. Interphase is not shown. The student appears to equate "Cell Cycle" with "mitosis of retinoblastoma cells" in the title above the drawing.
4	3	The student states that the DNA of the retinoblastoma cells would result in the production of abnormal proteins and that cancer would result through accelerated cell division.

Total = 13 13/4 = 3.25 Mark = 3

Technology and Society Score—3

Scoring Guide Bullet	Score	Rationale
1	4	The student performs a cross involving a "normal" individual and a heterozygous individual. The Punnett square is correct; however, the interpretation of the results is not quite correct. The student has indicated that there is a 50% chance of retinoblastoma occurring when, in fact, 50% of the children will have the risk factor and be carriers of the abnormal allele.
2	2	A method for decreasing the incidence of the disease is suggested. While a method for decreasing the incidence of the disease allele is identified, the explanation "DNA reconstruction maybe could be done in the Future" is not definitive enough to merit a score of 3. Also, the student does not explain how "monitoring individuals" so that the disease can be "caught early" will eliminate the disease.

Total = 6 6/2 = 3.0 Mark = 3

Final Score		
	3(2) = 6/10	Science
	3/5	Technology and Society
	9/15	Final Score

An important point to note about the scoring guide is that a score of 1 is awarded if only one of the four bullets making up the Science scoring scale for the question is answered. Even if the student receives a very high score on the first bullet, he or she will receive a score of 1 because he or she has not addressed the three other bullets (3/4 of the question). For the Technology and Society scoring scale, a score of 1 is given if only one of the two bullets is addressed and it is scored as either 3 (Satisfactory) or 2 (Limited). If more than one bullet is addressed by the student, the student automatically receives a score of 2 or higher for the answer.

General Comments About the Open-Response Scoring Guide

The difference between an answer receiving a score of 2, 3, 4, or 5, on either scale, depends on the amount of detail that is supplied in the answer, the clarity of the communication, and whether the student addresses all portions of the question. If the student is able to support his or her answer through the use of diagrams, appropriate vocabulary, and technologies, then a higher score is assigned.

Students can turn a poor answer into an excellent one by addressing each aspect of the question specifically.

For example, one part of the retinoblastoma question required students to "**Provide** the necessary details of the physiology of the eye and brain."

In student sample 3 (page 24), the student gave the following response.

> "Cones and rods are used to see color and shades of grey respectively. The different images they receive are transmitted to sensory nerves and then to the brain."

An excellent response would be more detailed and specific, as in the following example.

> Light stimulates the cones (high-intensity light) and rods (low-intensity light) thereby permitting colour vision and vision in shades of black and grey, respectively. The rods and cones act as sensory receptors. Once excited by light, they stimulate impulses in the optic nerve. The optic nerve carries the impulses to the occipital lobe of the cerebrum where they are interpreted.

Course Clarification: Major Concept 3 (Embryology)

Cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine, and environmental influences.

On October 18 and 19, 1999, a committee of teachers and Alberta Learning staff met to discuss the teaching and evaluation of this major concept in the Biology 30 curriculum. The purpose of the discussion was to obtain information that would help teachers interpret the depth and breadth of coverage intended by the curriculum. This information will also be used by Alberta Learning to determine appropriate evaluation of this major concept on the Biology 30 diploma examinations. The results of these discussions were clarifications that may also be useful in the revisions of the Biology 20–30 *Program of Studies* planned for 2006. Staff from the Curriculum Branch of Alberta Learning was involved in the process, reviewed the clarifications, and felt that this type of communication with teachers was appropriate. In addition to clarifying the content of this major concept, the committee discussed possible teaching strategies and resources that teachers could use. This document includes a summary of these ideas and a list of resources.

Content Clarification

The first specific learner expectation (SLE) is: ... *tracing the process of fertilization, implantation, extraembryonic membrane formation (e.g., amnion, chorion, yolk sac, placenta), embryo development,* *parturition, lactation, and the control mechanisms of those events; progesterone, LH, chorionic gonadotropin, oxytocin, prolactin*

The two sub-themes within this SLE were identified as:

- processes in the early stages of human development
- hormonal control mechanisms of pregnancy, birth, and lactation

The committee did not feel that clarification of hormonal control mechanisms was necessary. The stages of development are continued in the second SLE. Teachers could create a continuous story about development if they combined the first and second SLEs.

The second SLE is: … *describing fetal development from implantation to full term in the context of the main physiological events that occur in the development of organ systems during each major stage (trimester) and the influence of environmental factors on the development of these systems: e.g., alcohol, drugs, pathogens*

Discussion of this SLE revealed that it could be interpreted to be equivalent to the entire content of a first-year university embryology course. Therefore, the committee concluded that clarification of a reasonable depth of coverage for this SLE would be useful to teachers.

The following points are a summary of the main content areas that teachers should consider as the minimum coverage for this SLE, listed in the order in which the events of human development occur.

- After fertilization occurs in the Fallopian (or uterine) tube, the **zygote** cleaves to produce two identical cells. Mitotic division continues, and a mass of cells moves down the Fallopian tube to the uterus.
- The mass of cells develops a hollow core and starts to be called the **blastocyst** at about the time that it implants itself in the uterus. The blastocyst will eventually form embryonic tissues and early embryonic membranes (chorion, yolk sac, amnion).
- The blastocyst is a critical stage of development that can be used to illustrate the importance of timing in normal human development; for example, if the chorion does not form and begins to secrete HCG, then a spontaneous abortion will occur; or if the inner cell mass does not form, then a molar pregnancy will result.
- The **chorion** is the embryonic portion of the **placenta**. The placenta is essential to the survival and growth of the embryo/fetus. It produces important hormones (e.g., HCG, estrogen, progesterone). It provides the membrane surface for exchange of nutrients, minerals, hormones, antibodies, gases and wastes between the fetal blood supply and the maternal blood supply. At the same time, it acts as a barrier between the fetal and maternal blood supplies. It is also the site where many **teratogens**

(environmental agents that induce developmental abnormalities) cross over from the maternal blood supply to the embryo/fetal blood supply.

- The **yolk sac** does not supply nutrients to a mammalian embryo as it does in birds, reptiles, and amphibians. It does, however, have several important functions (e.g., it is the early source of red blood cells before the embryo produces its own, it forms a portion of the digestive tract, and it is the source of the primordial germ cells).
- The **amnion** will eventually surround the embryo, enclosing it in a fluid-filled sac. This fluid-filled sac serves several functions including cushioning the embryo from impact to the mother, temperature control of the embryonic environment, protection of the fetus from infection, and enhancing muscle development, joint development, and neural connections by allowing the fetus to move more freely.
- At the end of the third week after fertilization, the embryo has developed into a three-layered disc. The process of forming the three layers is called **gastrulation** and involves the migration of cells between the two layers of cells found in the blastocyst. It is this three-layered disc that gives rise to the various tissues and organs of the embryo. The **ectoderm**, or outer layer, gives rise to the epidermis (skin, hair, etc.) and the nervous system. The **mesoderm**, or middle layer, gives rise to the muscle, bone, and blood vessels. The **endoderm**, or inner layer, gives rise to the linings of the digestive and respiratory tracts.
- Development of organs and organ systems from the three embryonic layers involves three main processes: growth; development of body form (morphogenesis), which includes precisely timed mass cell movements and their interaction; and differentiation that results in the formation of functional organs and organ systems. The development of organ systems occurs primarily from the fourth to eighth week of human development (during the first trimester). This is the time period when the fetus is most likely to develop abnormalities as a result of exposure to teratogens. A chart of some teratogens and their possible affects on embryonic development is included on pages 34 to 36 of this document.
- The timing of events in human development allows researchers to determine the approximate range of time that exposure to a particular teratogen may have occurred to produce a developmental abnormality. In many cases, the damage occurs before a woman is aware that she is pregnant.
- A reasonable teaching strategy that could be used to illustrate the processes of development, the importance of timing, and the effects of genetic, endocrine, and environmental influences on human development would be to describe the development of **one** organ, structure, or system. Examples include:

  - formation of facial features—cleft palate caused by exposure to the teratogen vitamin A (used as an acne treatment) or as a result of inherited factors
  - formation of abnormal limbs due to exposure to the teratogen thalidomide, or of extra digits on limbs as a result of a dominant inherited gene
  - formation of the nervous system—mental retardation due to fetal alcohol syndrome, toxoplasma gondii (a parasite that also infects cats), or the rubella virus (German measles), spina bifida (which has been linked to several environmental and nutritional factors)
  - formation of the eye—cataracts due to the rubella virus
  - formation of the heart—abnormalities due to exposure to vitamin A

- The second and third trimesters of development are primarily periods of growth. Important development of some key structures, including the lungs and nervous system, continues to occur. Alcohol and other teratogens can still cause mental retardation late in pregnancy. Babies born at the end of the second trimester can survive. Lung development is sufficient by 26 to 28 weeks for a premature infant to survive. In the third trimester, fat is deposited.

The third SLE is: *…describing the physiological or mechanical basis of different reproductive technology methods; e.g., conception control, in vitro fertilization, infertility reversal*

The committee did not feel that clarification of the physiological or mechanical basis of different reproductive technology methods was necessary.

Skills and STS Connections for Major Concept 3

The committee suggested that the skills and STS connections section of the *Program of Studies* could provide ideas for a variety of teaching strategies that integrate the knowledge, skills, and STS connection components. This integration assists students in drawing connections between the knowledge, skills, and STS components of Major Concept 3 and engages students in critical thinking activities on this concept.

Emphasis of Major Concept 3 as Represented in the Blueprint

The examination specifications in this Bulletin state that the examinations are constructed such that they place approximately 5% to 10% of the emphases on the knowledge component of this major concept. The skills and STS emphases on the examination are not broken down by individual learner expectations. (The emphasis is 20% to 30% for skills and 20% to 30% for STS.) Questions are always identified in the examination blueprint as a knowledge GLE and may also be identified as having a skill or STS emphasis. Therefore, when an exam is constructed, 5% to 10% of the questions will test this major concept (GLE).

Biology 30, like other courses worth five credits, is assigned 125 hours of course time. If teaching time reflects the emphasis on the examination, then between seven and 13 classes (of 60 minutes each) would be spent working with students on this major concept of the curriculum.

List of Resources

Print Resource

Moore, K.L. and T.V.N. Persaud, 1993. *Before we are born.* Philadelphia: W.B. Saunders Company.

Internet Sites

- *Dynamic Development*
  http://www.ucalgary.ca/UofC/eduweb/virtualembryo/db_tutorial.html
  A comprehensive embryology web site created by the University of Calgary that includes visual images of developing embryos of a number of different species, current developmental biology research, and links to related learning resources.

- *Morehouse School of Medicine*
  http://www.msm.edu/human_morph/embryo/embryo.htm
  A very useful list of embryology sites created and maintained by a number of university embryology departments. The sites include detailed information on human development and several animations illustrating human development.

- *Human Embryology On-line Text*
  http://www.med.uc.edu/embryology/contents.htm
  Human embryology is a site that details the weekly events of human development through text, static images, and animation. This site could be used to illustrate the processes of human development of one organ, structure, or system.

- *Chickscope*
  http://chickscope.beckman.uiuc.edu/
  Chickscope is a student-focused educational resource that details the events of chicken development. This site could be used as a student resource to observe the stages of chicken embryonic development.

- *Table of Known Human Teratogens*
  http://www.mostgene.org/gd/gdvol12h.htm
  This table has been adapted for classroom use on pages 34 to 36 of this document.

- The University of California San Francisco *In Vitro* Fertilization web site
  http://www.ihr.com/ucsfivf/index.html

Some Known Human Teratogens

Medications

Teratogen	Most Common Congenital Anomalies
Thalidomide (tranquilizer and sedative)	Limb reduction defects, ear anomalies, heart defects
Diethylstilbestrol (DES)	Abnormalities of the uterus and vagina
Warfarin (anticoagulant)	Exposure at six to 12 weeks: incomplete nasal cartilage, stippled epiphyses (growth area of the long bones), central nervous system defects Exposure in the second and third trimester: eye anomalies, mental retardation
Trimethadione (anticonvulsant)	Developmental retardation, facial abnormalities (v-shaped eyebrows, low-set ears, cleft lip and/or palate)
Aminopterin and methotrexate (tumour inhibiting chemicals)	Inhibits mitosis in rapidly dividing cells resulting in serious defects Pregnancy loss, malformation of the central nervous system (including absence of most of the brain), craniofacial abnormalities
Streptomycin (antibiotic)	Hearing loss
Tetracycline (antibiotic)	Exposure in the second or third trimester: yellow-stained teeth, other tooth enamel defects
Valproic acid (anticonvulsant used in epilepsy treatment)	Neural tube defects, craniofacial anomalies, heart defects, limb defects
Isotretinoin (Rentinoic acid or vitamin A used in acne treatment)	Exposure at three to five weeks: pregnancy loss, neural tube defects, brain defects, small or absent thymus, heart defects, craniofacial abnormalities (small ears, small jaws, cleft palate)
Antithyroid drugs and potassium iodide found in cough mixtures	Hypothyroidism (cretenism), goiter
Androgens and high doses of nor-progesterone	Exposure in the first trimester: masculinization of external female genitalia
ACE inhibitors (anti-hypertension agents)	Low volume of amniotic fluid, fetal death, renal dysfunction, skull ossification defects
Lithium (manic-depression treatment)	Heart and major blood vessel anomalies

Maternal Infections

Teratogen	**Most Common Congenital Anomalies**
Rubella virus (German measles)	Exposure in the first trimester: heart and blood vessel anomalies, small brain, hearing loss, eye defects (glaucoma and cataracts), post-natal growth delay
Toxoplasmosis (caused by a parasite that commonly infects cats)	Various brain defects, blindness, mental retardation
Varicella (chickenpox)	Exposure in the first four months: skin scarring, limb reduction defects, muscle atrophy, mental retardation, rudimentary digits
Syphilis (micro-organism)	Abnormal teeth and bones, mental retardation
Cytomegalovirus	Exposure in the first trimester: fatal to most embryos Exposure later in pregnancy: growth and developmental retardation, small brain, hearing loss, occular abnormalities, cerebral palsy
Herpes	Pregnancy loss, growth retardation, eye abnormalities, transmission to infant most commonly occurs at delivery

Chemical

Teratogen	**Most Common Congenital Anomalies**
Organic mercury (often found in contaminated fish)	Cerebral atrophy, spasticity, mental retardation, blindness Minamatu disease: characterized by neurological and behavioural disturbances that resemble cerebral palsy
Lead	Pregnancy loss, central nervous system damage
Polychlorobiphenyls (PCBs) ingested	Low birth weight, skin discolouration

Maternal Disorders

Teratogen	**Most Common Congenital Anomalies**
Diabetes mellitus (if poorly controlled)	Congenital heart defects, neural tube defects, limb defects, vertebral anomalies, pregnancy loss
Hypo/hyperthyroidism	Goiter, growth and developmental retardation
Phenylketonuria (PKU) left untreated	Pregnancy loss, small brain, mental retardation, facial abnormalities, congenital heart defects
Hypertension	Intrauterine growth retardation
Autoimmune disorders	Congenital heart block, pregnancy loss

Other Reproductive Toxins

Teratogen	**Most Common Congenital Anomalies**
Cigarette smoking	Pregnancy loss, low birth weight
Hyperthermia	Neural tube defects
Chronic alcoholism or binge drinking	Fetal alcohol syndrome: growth and developmental retardation, abnormal facial features (widely spaced eyes, thin upper lip)
Therapeutic radiation	Growth and developmental retardation, small brain, spina bifida, retinal pigment changes, cataracts, cleft palate
Cocaine	Pregnancy loss, placental abruption, growth retardation, small brain, neurobehavioural disturbances, urogenital anomalies

2000–2001

Internet Sites Recommended For Alberta Students and Teachers

The Internet sites listed below can be used as resources by both students and teachers of Biology 30 and may assist with the integration of the ICT outcomes into the teaching and learning of Biology 30.

- *Howard Hughes Medical Institute*
  http://www.hhmi.org/grants/lectures/webcast/1998.htm
  The site offers a series of webcast lectures on human genetics and neurobiology.

- *See the World Through the Eyes of a Honeybee*
  http://cvs2.anu.edu.au/andy/beye/beyehome.html
  A site that allows us to experience what some common objects look like through the eyes of a honeybee. The site also features an interactive component where scanned pictures and photographs of your choice can be viewed.

- *National Center for Biotechnology Information Gene Bank*
  http://www.ncbi.nlm.nih.gov/Genbank/GenbankSearch.html
  A site consisting of an information database of amino acid sequences that can be downloaded for study. These sequences can be used to trace evolutionary relationships between various organisms.

- *Obstetric Ultrasound*
  http://www.ob-ultrasound.net/
  The site offers a detailed description of the uses of obstetric ultrasound accompanied by ultrasound images showing weekly stages of human fetal development.

- *A Predator–Prey Simulation*
  http://www.basmark.com/ljl/wator/
  WATOR is a computer simulation of the interaction, over time, of predator and prey in a small area. The purpose of the simulation is to continually alter the parameters so that the populations stay stable as the area is reduced in size.

- *Fox and Rabbit Predator-Prey Growth Model*
  http://cauchy.math.colostate.edu/Applets/PredatorPrey/predatorprey.htm
  This site illustrates a predator–prey growth model for foxes and rabbits, given initial fox and rabbit population numbers and a specified growth rate for the rabbit population.

- *Georgia State University Biology Interactive Activities*
  http://www.gsu.edu/~wwwsci/biology.htm
  The site offers a variety of interactive activities including performing genetic crosses using Punnett squares, dissection of a cow's eye, population studies, an

investigation of Mendel's pea experiments, investigations of how the senses work, and the processes involved in protein synthesis.

- *Genetic Simulations on the TI-83*
  http://www.iserv.net/~gopat/tigenes.htm
  The site includes instructions on how the TI-83 calculator can be used to perform a number of genetic simulations including meiosis, and monohybrid and dihybrid crosses.

1999–2000

Internet Sites Recommended For Alberta Students and Teachers

The following list of Internet sites can be used as resources by both students and teachers of Biology 30. When accessing electronic information, it is important to evaluate the authority, reliability, and validity of the information and to identify and analyze factors that affect the authenticity of the information.

- *Access Excellence®: A Place in Cyberspace for Biology Teaching and Learning*
  http://www.accessexcellence.org/
  The site includes links to *What's News* in biology–related research, issues and ethics in biotechnology, a biology activities exchange, and a sampling of online collaborative projects.

- *The Center for Molecular Neuroscience: Online Journal Links*
  http://www.mc.vanderbilt.edu/brainscience/journlinks.html
  A Vanderbilt University School of Medicine site that includes links to many recognized science journals related to the human nervous system such as the *Journal of Molecular Neuroscience, Behavioral and Brain Sciences, On the Brain*, and the *Scientific American Journal.*

- *The Virtual Embryo*
  http://www.acs.ucalgary.ca/~browder/
  A University of Calgary site that includes visual images of developing embryos of a number of different species, current developmental biology research, and links to related learning resources.

- *The Multi-Dimensional Human Embryo*
  http://embryo.mc.duke.edu/
  A collection of magnetic resonance images of developing human embryos.

- *National Center for Biotechnology Information*
  http://www3.ncbi.nlm.nih.gov/
  A site that includes several links related to Mendelian and molecular genetics such as the *Human Genome Project*, genes and disease, and *The Online Mendelian Inheritance in Man.*

- *Links to Human Disease Related Pages*
  http://wsrv.clas.virginia.edu/~rjh9u/disease.html
  A site that includes several links related to human disease such as cystic fibrosis, Mad Cow Disease, Thalassemia, hemophilia, Down syndrome, Turner syndrome, Klinefelter syndrome, and others.

- *Canadian Wildlife Service*
  http://www.cws-scf.ec.gc.ca/cwshom_e.html
  A site featuring Canadian species' population information including links to current population research and government publications related to populations.

Hardy–Weinberg Calculations

The January 1999 written-response question 2 asked students to calculate the frequency of a particular allele and the percentage of a given population that are carriers. The question also required students to show their work. Two examples of hypothetical students' responses are presented below. These show common errors in communication and the mark, out of 5, that each student would have received for their answers. The information given was that 1/40 000 individuals in the population have the autosomal recessive disorder.

Hypothetical response 1:

$$q = \frac{1}{40\,000} = 0.000025$$

The frequency of the allele is 0.25%

$$p = 1 - 0.25$$

$$p = 0.75$$

$$2pq = 2(0.75)(0.25) = 0.375$$

The percentage of carriers in the population is 37.5%.

This student's initial error is to confuse the frequency of the disorder with the frequency of the recessive allele. It is a common error for students to incorrectly use the allele frequency for the disorder frequency and vice versa. Students should be comfortable doing calculations using both types of starting data. Phenotypic evidence can be used to determine the frequency of a disorder. Genetic screening tests, if available, can be used to determine the frequency of an allele.

Although this student's first calculation is incorrect, the second calculation, using the incorrect value for p is correct. Therefore, this student would have received a 3/5 for the communication and calculations.

Hypothetical response 2:

$$q^2 = \frac{1}{40\,000}$$

$$q = 0.005$$

$$p = 1 - q = 0.75$$

$$p^2 = 0.99$$

$$2pq = 2(0.005)(0.995) = 0.00995$$

Although this student's mathematical communication is accurate, he or she failed to state the answer to the second part of the question, which required students to "calculate the percentage of the population that are carriers." (Answer: Approximately 1.0% of the population are carriers). The marker is therefore unsure of whether the student knows the meaning of the mathematical symbols he or she is using. This student would have received a 4/5 for this portion of the answer.

Implementation of the New Open-Response Scoring Guide

The new scoring guide was implemented in the February marking session of the January 1999 Diploma Examination. This marking session provided positive evidence that the new scoring system is fair to students, reliable, provides additional information for students and educators, and effectively differentiates different levels of student achievement.

The scoring system uses two scales, one for science and one for technology and society. Jurisdiction and school reports provide information on student performance for both scales. In conjunction with the examination itself, these reports can be used to better interpret specific areas of student strengths and weakness. Teachers surveyed during the February marking session felt the new information available with this scoring guide would be helpful in analyzing results. The provincial results from the January 1999 Diploma Examination can be used to illustrate this. The technology and society scale results for the question revealed a higher proportion of no responses and zeros and a lower average than the science scale results. Many students had difficulty attempting Hardy–Weinberg calculations and were not able to describe technologies or societal factors that might be reasonable solutions to the problem stated. This is an area of the curriculum that teachers in the province could target for improved learning strategies for students. However, there was a higher proportion of students receiving perfect scores on this scale than on the science scale. This result suggests targeting these strategies to students at the *acceptable standard* of achievement rather than students achieving at the *standard of excellence*. Individual, school, and jurisdiction reports would enable educators to determine if these were problem learning areas for their group of students.

The division of the scoring criteria into two scales with five divisions each provides more information to students and teachers on how to achieve an acceptable or excellent standard of achievement on this portion of the exam. The increased number of divisions produces more identifiable steps for improvement. The scoring guides for each examination are available on the Internet to teachers and students and could be used to evaluate students' ability to answer this type of question and then illustrate what would be required to improve their score. The greater number of divisions in the scale should allow students to identify a reasonable improvement goal.

Teachers surveyed during the February marking session felt that the new scoring guide was fair to students. Many commented that the scoring criteria described students' achievement better than the one-scale, four-point scoring system that was replaced. Students were less likely to have responses that fell between the achievement levels described. A very low third-read rate (less that 1%) in February supports the teachers' comments that student achievement was assessed consistently and fairly using this scoring method.

Marks ranging from 0/15 to 15/15 were awarded using this scoring method. The one-scale, four-point scoring system only allowed eight different marks to be assigned to students based on the quality of their responses. (The *Examiners' Report* for January 1999, available to teachers on the extranet provides a graph of the distribution of these marks on the January 1999 examination.) The new scoring system was very effective in differentiating students' levels of achievement.

1998-1999

Development of the New Open-Response Scoring Guide

The change from one 0- to 4-point scoring scale to two 0- to 5-point scoring scales was a result of a year of research, consultation, and trial.

A Scoring Review Committee was organized and several scoring systems were studied. A group decision was made to try using two scoring scales that each had six points. For each open-response question field-tested in 1998, "Science" and "Technology and Society" scales were written by members of the Scoring Review Committee. Care was taken to ensure that the standards required at each of the six levels in each scoring scale were approximately equal for each field test. The January 1998 field tests were scored using this new system. The results were analyzed and were judged to be favourable. The student score distributions appeared to be less clumped than they have been in the past when the one 0- to 4-point scoring scale was used. The overall scores were slightly higher than with the previous scoring system. Based on this positive outcome and on the recommendations of the Assistant Director, Student Evaluation Branch, a pilot study was undertaken. The essay question of the April 1998 examination was scored using both scoring systems: the original 0- to 4-point scoring scale, applied two times to each response, and the new two 0- to 5-point scoring scales, applied once to each response. **The original scoring system was used to determine the students' mark**, therefore, it required two applications. Although the new scoring system is designed to be applied two times to each response, this was not necessary for this study. The final score distribution was better with the new scoring system than it was with the original scoring system. There were more As, fewer Fs, and fewer 0s with the new scoring system. There was better student separation with the new scoring system, as exemplified by fewer large clumps. There was a 7.6% increase in the mean of this open-response question when the new scoring system was applied. This increase in mean would have resulted in a 1.0020% increase in the overall mean on the examination. A statistical test determined this to be a significant increase. When individual student final scores on their open-response were analyzed, only 27.9% of the students' scores would have decreased if the new scoring system was used. As well, 13.4% of the students' scores would not have changed, and 58.7% of the scores would have increased if the new scoring system was used. Based on this comparison of the new scoring system with the original scoring system, as they were applied to the April 1998 open-response question, the new scoring system differentiated student levels of achievement better, distributed scores better, and raised the mean on the question and on the whole examination. **The new scoring system appears to be a more fair and appropriate scoring system than the original scoring system; therefore, permission was granted to use this new scoring system to score the essay question on the Biology diploma examinations from January 1999 onward.**

Members of the Scoring Review Committee
Richard Baron, Wild Rose School Division #66
Ruth Benda, Calgary School District #19
Duncan Buchanan, Edmonton Catholic Regional Division #40
Karen DeWeert, Peace River School Division #10
Barry Emerson, Lethbridge School District #51
Darrell Feschuk, Foothills School Division #38
Deborah Gargus, Elk Island Public School Reg. Div. #14
Lillian Hampel, Edmonton School District #7
Henry Szydlik, Lakeland RCSSD #150
Andy Valadka, Calgary RCSSD #1

the scores would have increased if the new scoring system was used. Based on this comparison of the new scoring system with the original scoring system, as they were applied to the April 1998 open-response question, the new scoring system differentiated student levels of achievement better, distributed scores better, and raised the mean on the question and on the whole examination. **The new scoring system appears to be a more fair and appropriate scoring system than the original scoring system; therefore, permission was granted to use this new scoring system to score the essay question on the Biology diploma examinations from January 1999 onward.**

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Science and Technology

The development of science is directly related to the development of technology, as is the development of technology related to advances in science. The word "technology" can have many meanings, but in general, the word refers to a way of doing something. This includes the development of new techniques for solving problems. It also includes ideas and their organization for achieving practical purposes. In the context of an examination question, the word technology will include all of these meanings. That is, a technological explanation should include not only identifications and descriptions of equipment (tools, products), but also explanations of how they may be used.

In biology, the science of molecular genetics is an area of active research and rapid growth. The advancement of genetic knowledge parallels the development of technologies that aid the study of DNA and patterns of inheritance.

In the *Biology 30 Program of Studies*, numerous genetic technologies are found in the sections of Knowledge, Skills, and STS Connections. Below is a list of some genetic technologies mentioned in the *Program of Studies*, their descriptions, and their uses. The curriculum emphasis is listed parenthetically. This list is provided as a clarification of genetic technologies that teachers may find useful for themselves and for instruction.

Technology Name	Technology Description	Use of the Technology
Genetic Counselling (STS)	Analysis of risk for genetic disorders in a family. Family histories are used to construct pedigrees that aid in calculating probabilities.	Used to present options available to avoid or reduce possible risks; also used to inform individuals o likelihood of developing late-ons genetic disorders based on family histories.

Genetic screening (STS)	Can involve biochemical tests that identify proteins indicative of certain genotypes. Can also involve complementary DNA probes if the sequences of the normal and mutant gene are known. DNA probes of a sequence complementary to both the normal and mutant alleles are exposed to a person's DNA sample. If both probes bind, then the person is a carrier.	Used to detect genes in people and advise them of their genotype. May aid in decision making.
Gene Bank (STS)	Storage site for the genetic material of a plant or animal species. The storage method varies according to the characteristics of the animal or plant; sometimes cryopreservation is used.	Used to preserve genetic diversity by ensuring a source of genes for endangered species and particular crop plants.
Gene Therapy (generally this term applies to humans only) (STS)	The transfer of genes into the genome of cells. Often uses a "disarmed" viral vector to carry the gene into the targeted host cell.	Used to treat heritable disorders caused by single-gene mutations, such as hypercholesterolemia, adenosine deaminase deficiency (ADA), and cystic fibrosis.
Gene Transfer (generally this term applies to non-human cells) (STS)	The transfer of genes into the genome of cells. Often uses a "disarmed" viral vector to carry the gene into the targeted host cell.	Used to place desired genes into host cells. For example, the human gene for factor IX (a blood-clotting factor) has been introduced into sheep cells, and the human growth hormone gene has been transferred into pig cells. These are often referred to as transgenic organisms.
Restriction enzyme/endonuclease (Knowledge, Skills)	An enzyme derived from bacteria that recognizes a specific DNA sequence and cuts the DNA at that sequence.	Used to cut DNA for the purposes of recombination or for DNA analysis during chromosome mapping or DNA fingerprinting.
DNA ligase (Knowledge, Skills)	An enzyme that can rejoin a broken bond in DNA.	Used to "seal" ends of DNA that have been cut by a restriction enzyme; often used during the process of DNA recombination.
Recombinant DNA technology (Knowledge, Skills)	The process of cutting out DNA from one genome and placing the DNA into another genome.	Used to transform bacteria, for example, so that the bacteria carry a gene from a different species.

Gel Electrophoresis (Skills)	DNA fragments are applied to a gel (often made of agarose). Electricity is used to allow them to penetrate and move through the gel. Smaller DNA fragments move through more easily and thus migrate farther than larger DNA fragments. A sample of proteins are applied to a gel (often made of polyacrylamide). Proteins can be negatively or positively charged, hence an electric current can be used to allow proteins to be first separated by charge and subsequently separated by size.	When combined with staining or X-ray film techniques, the patter observed are used to determine t presence or absence of particular DNA segments or proteins. Specific bands of DNA or protei can also be retrieved from the ge
DNA Fingerprinting (STS)	A sample of DNA is cut with restriction enzymes—this produces a number of DNA segments of different lengths. Because each individual has a unique DNA sequence (genome), each individual will have a different number of sites where the enzyme will cut. This results in a unique number and length of DNA segments for each individual. These DNA segments produce a unique banding pattern (“fingerprint”) when analyzed using gel electrophoresis.	Used to determine paternity and provide evidence in court cases. Used in many species to help establish kinship.
Genetic Engineering (STS)	A general term that refers to the alteration of an organism’s genome by selectively removing, adding, or modifying DNA.	Used to produce genetically altered organisms that possess desired traits or that lack undesirable traits.
Biotechnology (STS)	A very general term that refers to the use of organisms or biological products for commercial and/or industrial processes.	Since this is such a general term, the specific use of organisms or biological products would have t be described.
Chromosome Mapping (also called linkage mapping or genetic mapping) (STS, Skills, Knowledge)	Recombination frequencies between genes are used to construct a map of a chromosome that places the genes found on that chromosome in a linear order.	Knowledge of genetic distances between genes allows one to calculate the probability of the appearance of recombinant genotypes and phenotypes in offspring.
Gene Map (Knowledge)	Usually refers to the sequence of bases of a single gene and the linear location of mutant sites that exist for that gene.	Knowledge of the different muta sites of a gene can be recorded efficiently.

Cloning (STS)	The artificial production of genetically identical copies of segments of DNA, genes, or cells. (Note: Cloning is a natural process as well. Many organisms, such as fungi, Aspen, and sea anemones, produce identical copies of themselves.)	DNA or gene clones are used to provide ample amounts of DNA or genes to work with in the laboratory. Cell lines are generally cell clones that are used to study the effects of drugs, etc., on those cells, and to study gene mutations in particular cells.

Science, Technology, and Society

The impact of science (biology) and technology on society (health care, food production, personal decision making, ethics, and public policy) has, for the most part, been very positive. However, as science and technology develops, ethical problems arise. In genetics, the social impact of new genetic developments is becoming more and more apparent. Ethical concerns arising from the use of genetic technologies should be considered. Equally important is a thorough understanding of the scientific basis of the genetics involved. Students should be able to apply their understanding of genetics to help them with their considerations of the use of genetic technologies.

In the *Biology 30 Program of Studies*, numerous genetic technologies are found in the sections of Knowledge, Skills, and STS Connections. A selection of some genetic technologies are described on pages 15 to 17 of this bulletin. For each genetic technology, ethical concerns arise. For example:

> Is the genetic information derived from **genetic counselling, genetic screening,** or **DNA fingerprinting** public or private information?
>
> To whom do the genes in the **gene bank** belong?
>
> Should the genes identified in the **Human Genome Project** be patented by the scientist who located and/or sequenced them?
>
> What are the implications of identifying, locating, and sequencing genes for various human characteristics?
>
> Is the use of viral vectors for **gene therapy/gene transfer** problematic?
>
> Who decides who should be a candidate for **gene therapy**?

Evaluate the possible uses of **DNA clones, cell clones,** or **whole organism clones**.

Issues in Science, Technology, and Society

An issue is a question that has no conclusive, correct answer or solution. As such, possible answers or solutions may raise disagreement about facts and their interpretation, or values and their importance.

The identification of an issue involves citing the question that is the basis of the disagreement. Questions arise when there are disagreements about the explanation of an event or the cause of an event. Questions also arise when there are disagreements about the value of a product or a process and its use in or by society.

The description of an issue includes not only an identification of the question but also some insight into the accuracy, support, and quality of proposed solutions or answers to the question.

Proposed answers or solutions may be based on common knowledge, common sense, personal observations, or reference to a respected or authoritative source. While no certain answers exist for issues, some answers are better or are more valid than others. An excellent description of an issue offers an intellectual analysis of solutions to the issue. An excellent analysis of the issue would be organized, thorough, and intellectually sound, and would be based on scientific information or evidence. Holistic scoring of "issues" and "decision-making" will be guided by these above principles.

Issues can be categorized into many types, two of which are society (societal) and technology (technological) issues. A societal issue results when a question arises about how people should live together or about how society will be (or has been) affected by a product, process, or event. A technological issue results when a question arises about the use of technology. If this use of technology also affects how people live together in a society, then the technological issue is also a societal issue.

Relationships Among

Mitochondrial DNA (and chloroplast DNA) is used to study the

Organisms of Different Species

relatedness (evolutionary distances) of organisms. It is preferable to use mitochondrial DNA (mtDNA) over nuclear DNA for two reasons. First, mtDNA accumulates random changes about ten times faster than nuclear DNA, so it is more useful in tracking recent events (recent in terms of evolutionary history). Second, mtDNA is inherited maternally, so that the lineage of inheritance can be traced back to one individual, rather than, for example, sixteen grandparents. MtDNA analysis can be used to determine kinship both within a species and between species.

1996-1997

Pedigree Analysis

A major clue for the identification of a dominant disorder is the appearance of the phenotype in every generation. Male and female parents transmit to both male and female children.

A major clue for the identification of a sex-linked recessive disorder is the presence of affected sons, as male offspring receive transmissions only from the mother, whereas female offspring receive transmissions from both the mother and father.

Abnormal alleles can arise de novo by mutation.

Chromosome Formation

Genetic material appears as fine, bumpy threads weaving through the nucleoplasm. Known as chromatin, each thread is a single molecule of DNA and protein until replication of the DNA results in each thread becoming a doubled molecule of DNA and protein held together by a centromere.

Following the replication of DNA, the chromatin coils and condenses enormously to form short, barlike bodies called **chromosomes**. At this time, each chromosome consists of two strands, or **chromatids**. During cell division (the processes of **mitosis** or **meiosis** [anaphase II]), the two chromatids of each **chromosome** are separated. Cells formed as a result of cell division contain one chromatid from each chromosome. The term **chromosome** is used to describe this single molecule of DNA and protein that now uncoils and becomes, once again, a fine, bumpy thread of **chromatin** in the nucleoplasm.

Counting Chromosomes

Replication yields chromosomes that appear doubled, two chromatids held by a centromere. Division yields chromosomes that are single. For an accurate count of chromosomes, count the centromeres.

Succession

This concept is traditionally explained as a process of change that occurs as a result of a disturbance. Succession is often described as a series of predictable changes in communities that result in a final, stable climax community. This explanation originated in 1916 by F.E. Clements and is directional and deterministic. Succession does not usually occur in this manner, but many high school textbooks perpetuate this misconception. A better description of succession de-emphasizes directionality and explains that disturbance produces new habitats, which leads to immigration, which affects communities that determine the gene pool. Immigration leads to colonization, which leads to emigration; with the net result being a change in character of the community or succession. No one final stage may exist since there may never be an absence of disturbance, or because the length of time between disturbances is insufficient, or because for some vegetation disturbance is necessary to maintain the community.

Graphing

A graph presents numerical information in a pictorial form. Three kinds of graphs are commonly used.

1. Line graph
   - used to display the relationship between continuous data
   - demonstrates a progession of values or shows how one variable changes in relation to another variable; for example, growth of a child with age.

   Note: When equations are graphed, a line is drawn.

2. Bar graph
   - used to display discrete or discontinuous data
   - consists of parallel bars whose lengths are proportional to quantities given in a set data. The items compared are plotted along the horizontal axis and appropriate measurement is plotted along the vertical axis. The numbers and types of protists in a lake may be illustrated in a bar graph.

3. Scatter graph
   - used to display the relation between two random variables
   - length of an experiment and number of bacteria grown may be illustrated in a scatter graph. A line of best fit may be shown on the graph.

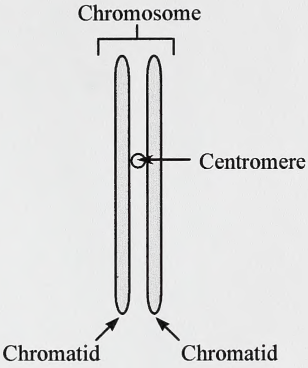
Generally, the same rules for graphing apply to all three types of graphs. These rules include:

1. The graph must have a title. The title represents the relationship between the two variables.
2. The independent (manipulated) variable is diagrammed on the horizontal X-axis.
3. The dependent (responding) variable is diagrammed on the vertical Y-axis.
4. Each axis is specifically labelled according to the variable it represents, and units are provided with equal increments. The scale does not have to be the same on both axes, but the scales must accommodate the ranges of the two variables.
5. Data are plotted. The graph may show exact numbers or a general relationship. A best fit line is often used in line and scatter graphs where a straight line is a rough linear estimate with values equally divided above and below the line.
6. A legend may be used to identify multigraph lines.

1995-1996

Chromosome Number Descriptions

Haploid and Diploid



A chromosome may consist of a single strand of genetic material or, following replication, two strands of genetic material (two chromatids) joined by a centromere.

A diploid cell has two sets of chromosomes, each chromosome consisting of either a single strand or a double strand of genetic material joined by a centromere. In the process of meiosis, the first nuclear division (meiosis I) reduces the number of chromosomes from the diploid number ($2n$, two homologous chromosomes of each parental type) to the haploid number (n, one chromosome of each parental type). Each of the two daughter cells produced by meiosis I contains one set of chromosomes, albeit, each chromosome consists of two strands joined by a single centromere. During meiosis II the centromeres divide and the two chromatids of each pair separate. The four cells produced are also described as haploid. A haploid cell has one set of chromosomes, each chromosome consisting of either a single strand or a double strand of genetic material joined by a centromere.

For a particular species, haploid (n) and diploid ($2n$) conditions can be distinguished in cells that are undergoing division by counting and comparing the number of centromeres.

Genetic Conventions

Probability

The convention followed in most current genetic journals and texts is to express probability as a decimal value. Therefore, if the word “probability” is used in a numerical-response question, a note will be provided requesting that the answer be expressed as a value from 0 to 1.

Names of Diseases

Current journals and texts use the non-possessive form of the name of the discoverer of a syndrome; e.g., Down syndrome, Turner syndrome, Klinefelter syndrome.